U. S. DEPARTMENT OF AGRICULTURE

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SOY BEANS

CULTURE *and* VARIETIES

THE SOY BEAN has been cultivated in China and Japan since ancient times and in extent of uses and value is the most important legume now grown in those countries.

Increased utilization of the soy bean in the United States has resulted in an enormous increase in acreage for hay, pasture, silage, and seed. It is estimated that more than 2,500,000 acres were grown in 1924.

The climatic adaptations of the soy bean are about the same as those of corn. It is more drought resistant and less sensitive to an excess of moisture than cowpeas and corn.

The soy bean will succeed in nearly all types of soil. The best results are obtained on mellow, fertile loams or sandy loams. The use of fertilizers is recommended in sandy soil or in soils of low fertility.

When soy beans are sown on land not previously planted to this crop it is advisable to inoculate the soil.

The selection of varieties suited to local conditions and to the purpose for which the crop is grown is one of the best assurances against failure.

The best time for seeding is about corn-planting time, or when the ground has become thoroughly warm. For seed production soy beans under nearly all conditions are seeded in rows and for forage in close drills. The quantity of seed required to the acre varies according to variety, method of planting, soil and climatic conditions, and the purpose for which the crop is grown. Soy beans should not be sown too deeply, as poor stands frequently result from too deep covering.

The soy bean may be used advantageously as either a seed crop or a forage crop in many systems of rotations. In combination with other crops, such as corn, cowpeas, Sudan grass, and sorghums, it furnishes a well-balanced ration, a large yield, and a great variety of forage.

Soy beans usually are comparatively free from serious insect pests. Grasshoppers, blister beetles, leaf hoppers, the Mexican bean beetle, and the green clover worm will occasionally feed on them.

Although the soy bean is affected by several destructive diseases in Asiatic countries, as yet no disease of the plant has assumed any great economic importance in America.

Rabbits are exceedingly fond of the soy bean and when numerous enough cause considerable damage.

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SOY BEANS: CULTURE AND VARIETIES

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HISTORY OF THE SOY BEAN

THE SOY BEAN[1] (fig. 1), also called the soja bean, the soya bean, and in North Carolina the stock pea, is a valuable annual leguminous plant, native of southeastern Asia. The wild form of the plant, a slender, twining vine with small pods and very small, dull black seeds, is known to occur in China, Manchuria, and Chosen (Korea). The culture and uses of the soy bean are recorded in ancient Chinese literature and undoubtedly date from a period long before the time of written documents. The soy bean has been a crop of prime importance in China and Japan since ancient times and in extent of uses is the most valuable legume now grown in those countries.

Previous to 1908 the trade in soy beans was largely confined to oriental countries, particularly China, Manchuria, and Japan. Since that time the value of the soy bean and its products has gradually been realized in other countries, and during the last decade they have attained considerable importance in the world's commerce. At the present time the soy bean is cultivated principally in China, Manchuria, Japan, Chosen (Korea), and the United States, but it is also of more or less importance in northern India, Indo China, and the Malayan Islands. Soy beans are grown also in Italy, France, southern Russia, Hungary, Hawaii, Egypt, South Africa, and in a few countries of South America, but the acreage in these countries is very limited.

The soy bean was introduced into the United States as early as 1804 and for several decades was regarded more as a botanical curiosity than as a plant of economic importance. Since 1890 nearly all of the State agricultural experiment stations have experimented with soy beans, and many bulletins have been published dealing

[1] *Soja max.*

wholly or partly with the crop. Previous to the numerous introductions by the United States Department of Agriculture beginning in 1898 there were not more than eight varieties of soy beans grown in the United States. With the introduction from Asiatic countries of varieties suited to the wide range of soil and climatic conditions in

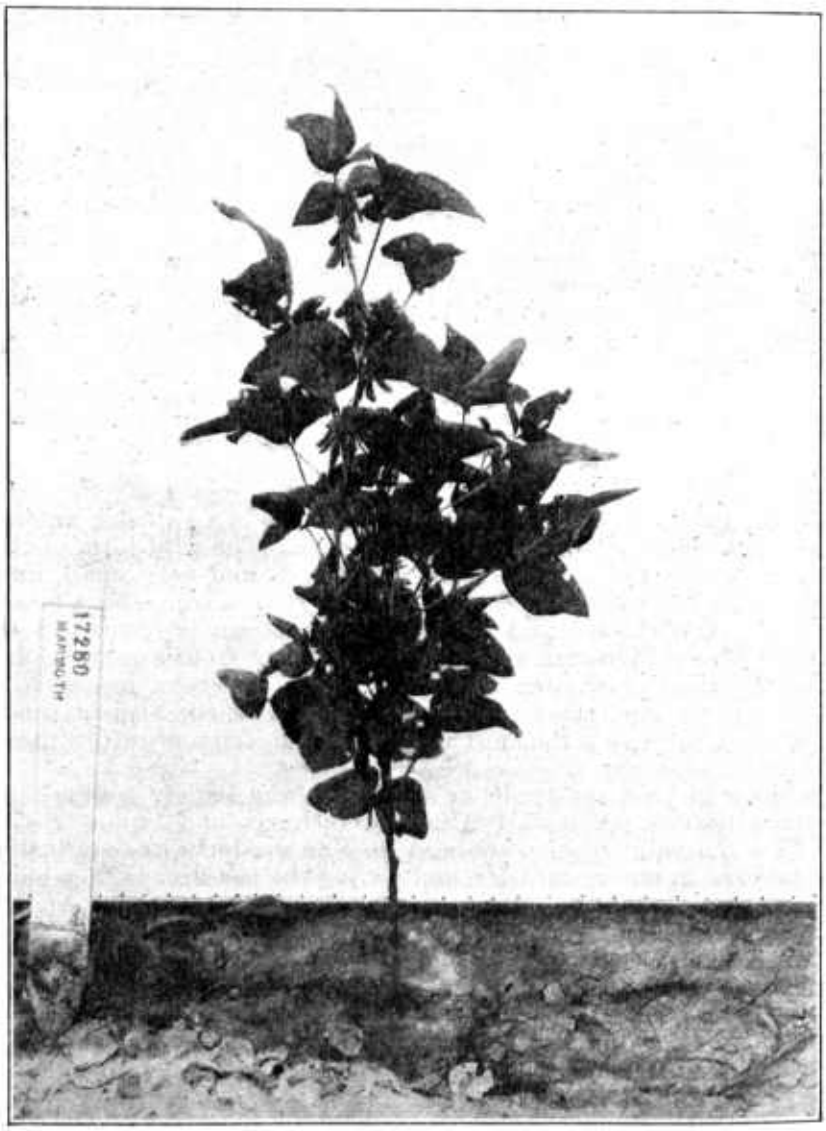

FIG. 1.—A typical soy-bean plant

the United States, the soy bean has assumed great importance in recent years and offers far-reaching possibilities to the future agriculture of this country.

The soy bean has been used mainly for forage purposes in the United States, but as a forage crop alone it would not likely become

one of the major field crops. The acreage in soy beans has increased very rapidly during the last decade. Previous to 1917 considerably less than 500,000 acres were grown. In 1924 there were more than 2,500,000 acres, of which 1,000,000 were grown for hay, 932,000 for pasture and silage, and 613,000 for the production of seed. More than 10,000,000 bushels of soy-bean seed and about 1,360,000 tons of soy-bean hay were produced in 1924. Although the increase in acreage has been general over the eastern part of the United States, the most marked increases have occurred in the Corn Belt and adjoining States and a few of the Southern States. In 1924 the five leading States for total acreage were Illinois (747,000 acres), Missouri (400,000), North Carolina (255,000), Indiana (210,000), and Tennessee (167,000); and for seed production, North Carolina (2,560,000 bushels), Illinois (1,548,000), Missouri (1,379,000), Ohio (728,000),

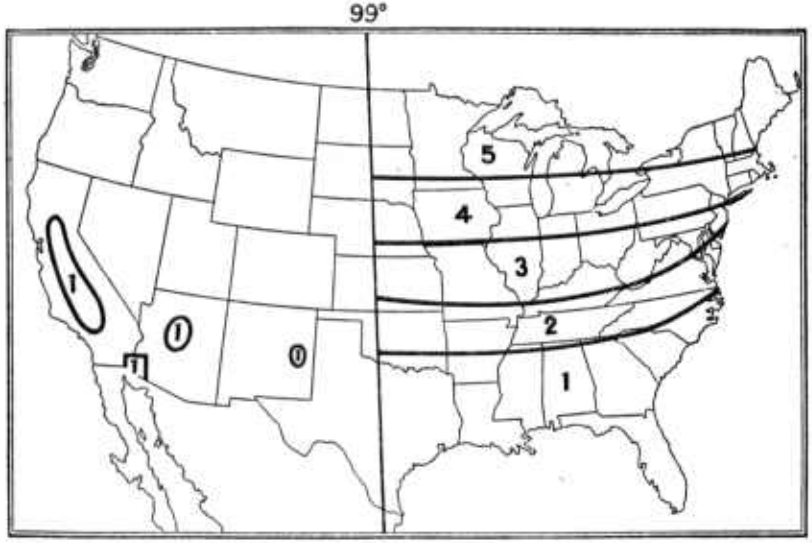

FIG. 2.—Outline map of the United States, showing by numerals the areas to which the soy bean is especially adapted. The varieties suited to the various areas for different purposes are discussed on page 11. Outside of the numbered areas the soy bean either can not be grown profitably or it is in the experimental stage

and Indiana 650,000). The acreage will undoubtedly continue to increase with improved methods and machinery for handling the crop and with greater utilization of the soy bean and its by-products for industrial purposes.

The large yield of seed, the excellent quality of forage, the ease of growing and harvesting the crop, its freedom from insect enemies and plant diseases, and the possibilities of the seed for the production of oil and oil meal and as human food, and the many ways in which the soy bean may be used, all tend to give the crop a high potential value.

CLIMATIC ADAPTATIONS

The climatic adaptations of the soy bean are about the same as for corn. (Fig. 2.) It is especially well adapted to the northern half of the Cotton Belt and the southern part of the Corn Belt, where

the larger and later varieties, which give yields that make their extensive cultivation profitable, can be grown. In the Northern States, however, early varieties introduced from northern Manchuria mature fair yields of seed, and later varieties can be grown successfully for hay, pasture, or silage. In the southernmost part of the Gulf States soy beans seldom develop seed normally, although an excellent growth of forage is produced. Similar conditions prevail in Arizona, New Mexico, and parts of California, where extremely hot weather prevails during the period when the seed is forming.

After the soy bean is well started it withstands short periods of drought, and a wet season neither seriously retards growth nor decreases the yield. The soy-bean plant seems to adapt itself not only to soils but to seasons as well. The period of germination is the most critical stage, when excess moisture or prolonged drought are likely to be injurious. The soy bean is less susceptible to frost than are cowpeas, field beans, or corn, light frost having but little effect on the plants when young or when nearly mature.

SOIL PREFERENCES

Although the soy bean will succeed on nearly all types of soil, the best results are obtained on mellow, fertile loams or sandy loams. In general, the soil requirements are about the same as those of corn, but the soy bean will make a more satisfactory growth than corn on soils low in fertility, provided inoculation is present. The crop will not make nearly such good growth on poor soils as cowpeas. On the heavier clays and on the lighter sandy soils the cowpea also succeeds better than the soy bean. The soy bean will do better than clover or alfalfa on soils of low fertility or on acid soils, but for the best results acid soils must be limed and poor soils must be supplied with those mineral elements in which they are deficient. With inoculation and moderate applications of fertilizers the soy bean gives good results on the sandy soils of the Coastal Plain area.

The soy bean does not necessarily require a well-drained soil, but it will not succeed where water stands on the surface for any considerable length of time. The crop grows well on drained swamp lands, provided acidity, when present, is corrected by the use of lime. Excellent yields of seed and forage are procured on some muck soils, and the crop is of considerable importance in regions where such soils occur.

VARIETIES

In the selection of a variety several factors should be considered, the most important of which are adaptation to local climatic and soil conditions and to the purpose for which the crop is grown. The number of soy-bean varieties is very large, and as many new ones are being introduced by growers and seedsmen the most desirable characters both for forage and for seed production need to be considered. Although yield of forage or of seed is the most important single consideration, other factors, such as maturity, habit of growth, coarseness, ability to retain leaves, color and size of seed, shattering, and disease resistance, are important. In those sections where the crop is likely to become of value for the produc-

tion of oil and oil meal, the percentage of oil and the color of the seed should be considered in addition to seed production. Manufacturers of oil and oil meal prefer the yellow-seeded varieties not only because of the higher oil percentage but also because the meal or flour is of better appearance.

In order to realize to the fullest extent the possibilities of the soy bean and to develop it agriculturally, it is important to utilize the very best varieties. At the present time about 45 varieties are handled by domestic growers and seedsmen. Unfortunately there is much confusion in the names of varieties, the same variety frequently being known under several different names. As new varieties are easily obtained through selection, crossing, and introduction, it is desirable to limit the varieties in trade to the very best. In many States where the soy bean is becoming an important crop the seeds of the best varieties are certified by crop improvement associations.

The planting of imported seed is not to be recommended. In general such seed consists of a mixture of varieties, most of which are inferior to those grown in this country. The United States Department of Agriculture and several State experiment stations have given considerable attention to the introduction, improvement, and adaptation of pure strains, and it is believed that in the planting of imported seed an unnecessary risk is taken. During the last 20 years more than 2,000 lots of seed for testing with a view to their introduction into this country have been received by the department from China, Manchuria, Japan, Chosen (Korea), Siberia, and India. Among these are many that have now become established on the market. Some of the recent introductions have proved to be so valuable in field trials that they are deemed important acquisitions, and seed will be distributed widely to further their culture.

Seedsmen and growers are urged to use the varietal names here adopted, and buyers should be careful to specify the variety desired. Moreover, in view of the fact that more or less fraud in varieties has been practiced because of the similarity in seed of certain sorts, the prospective purchaser should buy seed from reliable sources only.

DESCRIPTIONS OF VARIETIES

The characteristics of the most important and recently improved varieties here described are based on varietal experiments conducted by the Bureau of Plant Industry at the Arlington Experiment Farm, Rosslyn, Va., near Washington, D. C. Extensive cooperative varietal investigations show that many of the varietal characters of the soy bean vary more or less with soil and seasonal conditions, cultural methods, locality, and source of seed. Therefore, varieties grown under different conditions from those of the Arlington Experiment Farm may vary more or less in maturity, habit of growth, percentage of oil, and size of seed.

A. K.—Commercial introduction from Manchuria, 1912. Plants stout, erect, bushy, maturing in about 110 days; pubescence (downy coating) both tawny and gray; flowers both purple and white, 50 to 55 days to flower; pods 2 to 3 seeded; seeds straw yellow with a light-brown hilum (seed scar), about 2,650 to the pound; germ yellow; oil 19.2 per cent.

Aksarben.—Introduced in 1913 by the United States Department of Agriculture under S. P. I. No. 36576 from Fakumen, Manchuria, where it is said to be grown extensively for the production of oil. Plants stout, erect, bushy, maturing in about 105 days; pubescence gray; flowers both purple and white, 40 to 45 days to flower; pods 2 to 3 seeded; seeds straw yellow with yellow hilum, about 2,675 to the pound; germ yellow; oil 19 per cent.

Arlington.—Introduced in 1908 under S. P. I. No. 22899 from Paotingfu, China, where it was said to be used as fodder for horses and mules and also for the oil which is expressed from the seed. Plants slender, erect, with twining terminals, maturing in about 125 days; pubescence both tawny and gray; flowers both purple and white, 60 to 65 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 4,750 to the pound; germ yellow; oil 15.3 per cent.

Austin.—Introduced under S. P. I. No. 6397 from Pingyang, Chosen, in 1901. Plants stout, erect, bushy, maturing in about 130 days; pubescence gray; flowers both purple and white, 55 to 60 days to flower; pods 2 to 3 seeded; seeds yellowish green with brown hilum, about 2,375 to the pound; germ yellow; oil 18.9 per cent.

Banner.—The same as Midwest.

Barchet.—Introduced under S. P. I. No. 23232 from Shanghai, China, in 1908. This variety is said to be grown as a second crop in low-lying rice fields and used mainly as forage for domestic animals. Plants slender, erect, but rather inclined to lodge on fertile soils, maturing in about 150 days; pubescence tawny; flowers purple, 80 to 85 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 9,950 to the pound; germ yellow; oil 13.3 per cent.

Biloxi.—Introduced under S. P. I. No. 23211 from Tangsi, China, in 1908. Plants stout, erect, bushy, maturing in about 165 days; pubescence tawny; flowers purple, 85 to 90 days to flower; pods 2 to 3 seeded; seeds dark brown with brown hilum, about 1,875 to the pound; germ yellow; oil 20.1 per cent.

Black Beauty.—The same as Ebony.

Black Eyebrow.—Introduced under S. P. I. No. 30744, from Wulukai, Manchuria, in 1911. Plants stout, erect, bushy, maturing in about 105 days; pubescence tawny; flowers both purple and white, 35 to 40 days to flower; pods 2 to 3 seeded; seeds black with brown saddle and black hilum, about 2,475 to the pound; germ yellow; oil 19.9 per cent.

Black Sable.—The same as Peking.

Bopp.—The same as Chernie.

Brown.—The same as Mammoth Brown.

Chernie.—Introduced under S. P. I. No. 18227 from Khabarovsk, Siberia, in 1906. Plants slender, erect, with twining tips, maturing in about 100 days; pubescence tawny; flowers purple, 40 to 45 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 4,675 to the pound; germ yellow; oil 17.3 per cent.

Chestnut.—Selection in 1907 from the Habaro variety at Arlington Experiment Farm, Va. Plants stout, erect, bushy, maturing in about 105 days; pubescence tawny; flowers purple, 40 to 45 days to flower; pods 2 to 3 seeded; seeds russet brown with brown hilum, about 3,275 to the pound; germ yellow; oil 18.3 per cent.

Chiquita.—Introduced under S. P. I. No. 27707 from Hankow, China, in 1910. Plants stout, erect, but under favorable conditions semierect with twining terminals, maturing in about 135 days; pubescence gray; flowers both purple and white, 65 to 70 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 4,050 to the pound; germ yellow; oil 17.6 per cent.

Columbia.—Introduced under S. P. I. No. 22897 from Paotingfu, China, in 1908. Plants stout, erect, bushy, maturing in about 125 days; pubescence gray; flowers both purple and white, 65 to 70 days to flower; pods 2 to 3 seeded; seeds green with brown hilum, about 3,350 to the pound; germ green; oil 18.7 per cent.

Columbian.—The same as Columbia.

Dixie.—Introduced under S. P. I. No. 37330 from Pingyang, Chosen, in 1914. Plants stout, erect, bushy, maturing in about 135 days; pubescence gray; flowers purple, 50 to 60 days to flower; pods 2 to 3 seeded; seeds straw yellow with yellow hilum, about 1,825 to the pound; germ yellow; oil 19.3 per cent.

Dunfield.—Introduced under S. P. I. No. 36846 from Fanchiatun Station, South Manchuria, in 1913. This variety is said to be highly prized for the quantity of oil which the seeds contain. Plants stout, erect, bushy, maturing in about 110 days; pubescence gray; flowers both purple and white, 40 to 45

days to flower; pods 2–3–4 seeded; seeds straw yellow with light brown hilum, about 3,175 to the pound; germ yellow; oil 19.8 per cent.

Early Brown.—Introduced by the Indiana Agricultural Experiment Station as a natural cross between the Ito San and Buckshot varieties. Plants stout, erect, bushy, maturing in about 110 days; pubescence tawny; flowers purple, 40 to 45 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 3,050 to the pound; germ yellow; oil 17.7 per cent. With the exception of color of seed, this variety can not be distinguished from Ito San.

Early Green.—The same as Medium Green.

Early Virginia Brown.—The same as Virginia.

Early Wilson.—The same as Wilson.

Early Wisconsin Black.—The same as Wisconsin Black.

Early Yellow.—The same as Ito San.

Easycook.—Introduced under S. P. I. No. 34702 from stock from Shantung Province, China, in 1894. Plants stout, erect, bushy, maturing in about 125 days; pubescence gray; flowers purple, 50 to 55 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 2,700 to the pound; germ yellow; oil 19.3 per cent. Especially suitable for food on account of ease of cooking.

Ebony.—Introduced under S. P. I. No. 6386 from Pingyang, Chosen, in 1901. Plants stout, erect, bushy, maturing in about 120 days; pubescence tawny; flowers both purple and white, 45 to 50 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 5,750 to the pound; germ yellow; oil 18.4 per cent.

Elton.—Introduced under S. P. I. No. 20406 from Khabarovsk, Siberia, in 1906. The Chinese are said to eat these beans boiled or sprouted before using. Plants stout, erect, bushy, maturing in about 105 days; pubescence gray; flowers purple, 40 to 45 days to flower; pods 2 to 3 seeded; seeds straw yellow with yellow hilum, about 2,625 to the pound; germ yellow; oil 17.4 per cent.

Essex.—The same as Peking.

Extra Early Black Eyebrow.—The same as Black Eyebrow.

Extra Select Sable.—The same as Peking.

Giant Brown.—The same as Mammoth Brown.

Goshen Prolific.—This variety is said to have originated as a sport or natural hybrid from the Ototan variety in eastern North Carolina. Plants slender, erect, bushy, lodging under favorable conditions, maturing in about 165 days; pubescence tawny; flowers purple, 90 to 95 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 6,300 to the pound; germ yellow; oil 12.7 per cent.

Green.—The same as Medium Green.

Guelph.—The same as Medium Green.

Habaro.—Introduced under S. P. I. No. 20405 from Khabarovsk, Siberia, in 1906. The Chinese are said to use the sprouts of this variety as a winter vegetable. The beans are also pressed for oil and the oil cake used as a feed for hard-working horses. Plants stout, erect, bushy, maturing in about 105 days; pubescence both gray and tawny; flowers both purple and white, 35 to 45 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 3,100 to the pound; germ yellow; oil 19.6 per cent.

Haberlandt.—Introduced under S. P. I. No. 6396 from Pingyang, Chosen, in 1901. Plants stout, erect, bushy, maturing in about 125 days; pubescence tawny; flowers both purple and white, 50 to 55 days to flower; pods 2 to 3 seeded; seeds straw yellow with dark-brown hilum, about 2,400 to the pound; germ yellow; oil 19.4 per cent.

Hahto.—Introduced under S. P. I. No. 40118 from Wakamatsu, Japan, in 1915. It is commonly known in Japan as "dove-killer," and is said to be used boiled in the green stage. Plants stout, erect, bushy, maturing in about 125 days; pubescence tawny; flowers purple, 55 to 60 days to flower; pods 2 to 3 seeded; seeds yellowish green with black hilum, about 1,250 to the pound; germ yellow; oil 17.9 per cent. Especially valuable as a green vegetable bean when three-fourths to full grown.

Hamilton.—Introduced by the Ohio Agricultural Experiment Station as Ohio No. 9035. Plants stout, erect, bushy, maturing in about 125 days; pubescence tawny; flowers purple, 50 to 55 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 2,075 to the pound; germ yellow; oil 19.2 per cent.

Herman.—Introduced by the North Carolina Agricultural Experiment Station as Haberlandt No. 38. Plants stout, erect, bushy, with a tendency to lodge on

fertile soils, maturing in about 140 days; pubescence tawny; flowers purple, 50 to 60 days to flower; pods 2 to 3 seeded; seeds straw yellow with dark-brown hilum, about 2,450 to the pound; germ yellow; oil 18.5 per cent.

Hollybrook.—Originally found mixed in Mammoth Yellow and introduced by T. W. Wood & Sons, Richmond, Va., in 1902. Plants stout, erect, bushy, maturing in about 135 days; pubescence gray; flowers white, 60 to 65 days to flower; pods 2 to 3 seeded; seeds straw yellow with light-brown hilum, about 2,550 to the pound; germ yellow; oil 18.2 per cent. The Midwest has been grown erroneously as Hollybrook in the Corn Belt States.

Hongkong.—Introduced under S. P. I. No. 22406 from Hongkong, China, in 1908. Plants stout, erect, bushy, maturing in about 120 days; pubescence both tawny and gray; flowers both purple and white, 50 to 55 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 3,125 to the pound; germ yellow; oil 20.5 per cent.

Hoosier.—Introduced under S. P. I. No. 30746 from Wulukai, Manchuria, in 1911. Plants stout, erect, bushy, maturing in about 110 days; pubescence gray; flowers both purple and white, 35 to 45 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 2,510 to the pound; germ yellow; oil 19.3 per cent.

Illini.—Pure-line selection from the A. K. variety made by the Illinois Agricultural Experiment Station. Plants stout, erect, bushy, maturing in about 105 days; pubescence gray; flowers white; 40 to 45 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 2,750 to the pound; germ yellow; oil 18.6 per cent.

Ilsoy.—Pure-line selection from the Ebony variety. Introduced by the Illinois Agricultural Experiment Station as Illinois 13–19. Plants slender, erect, maturing in about 120 days; pubescence tawny; flowers purple, 45 to 50 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 3,250 to the pound; germ yellow; oil 16.0 per cent.

Indiana Hollybrook.—The same as Midwest.

Ito San.—Obtained by the Kansas Agricultural Experiment Station from Japan in 1890. Plants stout, erect, bushy, maturing in about 110 days; pubescence tawny; flowers purple, 35 to 45 days to flower; pods 2 to 3 seeded; seeds straw yellow with yellow hilum and a small brown speck at one end of hilum, about 3,325 to the pound; germ yellow; oil 16.9 per cent.

Jet.—Introduced under S. P. I. No. 17861 from Sachow, China, in 1906. The Chinese are said to use this variety mainly for forage. Plants slender, erect, with twining terminals, maturing in about 125 days; pubescence both gray and tawny; flowers both purple and white, 50 to 55 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 3,760 to the pound; germ yellow; oil 18.5 per cent.

Laredo.—Introduced under S. P. I. No. 40658 from Yangpingkwan, China, in 1914. In China this variety is said to be adapted to drier lands than other varieties. Plants slender, erect, inclined to lodge on fertile soils, maturing in about 140 days; pubescence tawny; flowers both purple and white, 70 to 75 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 7,775 to the pound; germ yellow; oil 14.0 per cent. The Laredo is highly resistant to wilt and nematodes.

Large Brown.—The same as Mammoth Brown.

Large Yellow.—The same as Mammoth Yellow.

Late Yellow.—The same as Mammoth Yellow.

Lexington.—Selection from the Sherwood variety at Arlington Experiment Farm, Va., in 1907. Plants stout, erect, bushy, maturing in about 125 days; pubescence gray; flowers both purple and white, 50 to 55 days to flower; pods 2 to 3 seeded; seeds yellowish green with brown hilum, about 3,585 to the pound; germ yellow; oil 19.1 per cent.

Mammoth.—The same as Mammoth Yellow.

Mammoth Black.—The same as Tarheel Black.

Mammoth Brown.—No definite information has been obtained as to the origin of this variety. Plants stout, erect, bushy, maturing in about 135 days; pubescence tawny; flowers purple, 65 to 70 days to flower; pods 2 to 3 seeded; seeds russet brown with brown hilum, about 1,855 to the pound; germ yellow; oil 16.5 per cent.

Mammoth Yellow.—Nothing definite is known regarding the origin of this variety. The Mammoth Yellow is the standard commercial variety. Plants stout, erect, bushy, maturing in about 145 days; pubescence gray; flowers

white, 85 to 90 days to flower; pods 2 to 3 seeded; seeds straw yellow with tawny hilum, about 2,150 to the pound; germ yellow; oil 18.6 per cent.

Manchu.—Introduced under S. P. I. No. 30593 from Ninguta, Manchuria, in 1911. The seed of this variety is said to be highly prized by the Chinese for its thin skin, high weight to the bushel, and high oil content. Plants stout, erect, bushy, maturing in about 110 days; pubescence tawny; flowers both purple and white, 35 to 45 days to flower; pods 2–3–4 seeded; seeds straw yellow with both black and brown hila, about 2,350 to the pound; germ yellow; oil 18.9 per cent. Early strains of Manchu having both brown and black hila are handled in some Northern States. A pure strain of Manchu with black hilum, but later than the ordinary Manchu, is now being grown.

Manchuria.—The same as Pinpu.

Mandarin.—Introduced under S. P. I. No. 36653 from Pehtuanlintza, Manchuria, in 1911. Plants stout, erect, bushy, maturing in about 100 days; pubescence gray; flowers purple, 35 to 40 days to flower; pods 2 to 3 seeded; seed straw yellow with yellow hilum, about 2,910 to the pound; germ yellow; oil 19.8 per cent.

Medium Early Green.—The same as Medium Green.

Medium Early Yellow.—The same as Ito San.

Medium Green.—Introduced from Japan in 1889 by W. P. Brooks, Massachusetts Agricultural Experiment Station. Plants stout, erect, bushy, maturing in about 115 days; pubescence tawny; flowers purple, 45 to 50 days to flower; pods 2 to 3 seeded; seeds green with brown hilum, about 2,485 to the pound; germ green; oil 19.5 per cent.

Medium Yellow.—The same as Midwest.

Merko.—Introduced under S. P. I. No. 20412 from Merkoechofka, Siberia, in 1906. Plants slender, erect, with twining terminals, maturing in about 115 days; pubescence both tawny and gray; flowers both purple and white, 45 to 50 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 4,900 to the pound; germ yellow; oil 16.4 per cent.

Midwest.—Introduced from central China about 1901. Plants stout, erect, bushy, maturing in about 115 days; pubescence tawny; flowers purple; 45 to 50 days to flower; pods 2 to 3 seeded; seed straw yellow with hilum varying from yellow to brown, about 3,675 to the pound; germ yellow; oil 15.4 per cent.

Mikado.—Selection from the Midwest variety by A. A. Parsons, Plainfield, Ind., in 1905. Plants stout, erect, bushy, maturing in about 120 days; pubescence tawny; flowers purple, 45 to 50 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 3,086 to the pound; germ yellow; oil 18.2 per cent.

Minsoy.—Introduced by the Minnesota Agricultural Experiment Station. Plants slender, erect, maturing in about 100 days; pubescence tawny; flowers purple, 30 to 35 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 3,700 to the pound; germ yellow; oil 16.2 per cent.

Mongol.—The same as Midwest.

Morse.—Introduced under S. P. I. No. 19186 from Newchwang, Manchuria, in 1906. This variety is said to be the most commonly used for oil extraction, the pressed cake being exported to Japan and southern China as a very valuable fertilizer. Plants stout, erect, bushy, maturing in about 130 days; pubescence gray; flowers both purple and white, 50 to 55 days to flower; pods 2 to 3 seeded; seeds yellowish green with brown hilum, about 2,500 to the pound; germ yellow; oil 18.1 per cent.

Ogemaw.—Introduced by E. E. Evans, West Branch, Mich., in 1902, as a cross between the Early Black and Dwarf Brown varieties. Plants stout, erect, bushy, maturing in about 90 days; pubescence tawny; flowers white, 30 to 35 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 3,125 to the pound; germ yellow; oil 17.5 per cent.

Ohio 9035.—The same as Hamilton.

Old Dominion.—Introduced under S. P. I. No. 44512 from Yihsien, Shantung, China, in 1917. It is said to be used as forage for livestock in China. Plants slender, erect, with twining terminals, inclined to lodge badly on fertile soils, maturing in about 140 days; pubescence gray; flowers purple, 70 to 75 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 6,525 to the pound; germ yellow; oil 13.8 per cent. Leaves persist when seeds are mature.

Otootan.—Introduced from the Hawaiian Islands in 1911 by C. K. McClelland, Georgia Agricultural Experiment Station. It is said to have come originally from Formosa. Plants slender, erect, bushy, but lodging under favorable con-

ditions, maturing in about 175 days; pubescence tawny; flowers purple, 90 to 95 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 6,150 to the pound; germ yellow; oil 17.7 per cent.

Peking.—Selection from the Meyer variety, Arlington Experiment Farm, Va., in 1907. Plants slender, erect, bushy, maturing in about 120 days; pubescence tawny; flowers both purple and white, 50 to 55 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 6,388 to the pound; germ yellow; oil 16.0 per cent.

Perley's Mongol.—The same as Midwest.

Pinpu.—Introduced under S. P. I. No. 28050 from near Harbin, Manchuria, in 1910. Plants stout, erect, bushy, maturing in about 105 days; pubescence gray; flowers purple, 35 to 40 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 2,675 to the pound; germ yellow; oil 18.4 per cent.

Red Sable.—The same as Peking.

Roosevelt.—The same as Midwest.

Roosevelt Medium Early Yellow.—The same as Midwest.

Royal.—The same as Wilson Five.

Sable.—The same as Peking.

Shanghai.—The same as Tarheel Black.

Sooty.—Selection from the Cloud variety at Arlington Experiment Farm, Va., in 1907. Plants slender, erect, with twining terminals, maturing in about 125 days; pubescence both gray and tawny; flowers both purple and white, 55 to 60 days to flower; pods 2 to 4 seeded; seeds rusty black with black hilum, about 5,825 to the pound; germ yellow; oil 12.9 per cent.

Southern.—The same as Mammoth Yellow.

Southern Prolific.—Introduced under S. P. I. No. 37250 from Seoul, Chosen, in 1914. Plants, stout, erect bushy, maturing in about 130 days; pubescence gray; flowers purple, 65 to 70 days to flower; pods 2 to 3 seeded; seeds straw yellow with light brown hilum, about 2,350 to the pound; germ yellow; oil 18.1 per cent.

Soysota.—Introduced by the Minnesota Agricultural Experiment Station. Plants slender, erect, bushy, maturing in about 100 days; pubescence tawny; flowers purple, 30 to 35 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 4,900 to the pound; germ yellow; oil 17.6 per cent.

Tarheel.—The same as Tarheel Black.

Tarheel Black.—Introduced under S. P. I. No. 14952 from Shanghai, China, in 1905. Plants stout, erect, bushy, maturing in about 140 days; pubescence tawny; flowers both purple and white, 70 to 75 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 2,710 to the pound; germ yellow; oil 18.6 per cent.

Tarheel Brown.—The same as Mammoth Brown.

Tokyo.—Introduced under S. P. I. No. 8424 from Yokohama, Japan, in 1902. Plants stout, erect, bushy, maturing in about 140 days; pubescence gray; flowers both purple and white, 70 to 75 days to flower; pods 2 to 3 seeded; seeds yellowish green with pale hilum, about 2,260 to the pound; germ yellow; oil 18.4 per cent.

Virginia.—Selection from the Morse variety at Arlington Experiment Farm, Va., in 1907. Plants slender, erect, with twining terminals, maturing in about 125 days; pubescence tawny; flowers purple, 50 to 55 days to flower; pods 2 to 3 seeded; seeds brown with brown hilum, about 3,455 to the pound; germ yellow; oil 17.9 per cent.

Virginia Early Brown.—The same as Virginia.

Wea.—Introduced under S. P. I. No. 30600 from Shuangchengfu, Manchuria, in 1911. This variety is said to be highly prized in Manchuria for its thin skin, heavy weight per bushel, and high oil content. Plants stout, erect, bushy, maturing in about 110 days; pubescence gray; flowers purple, 35 to 40 days to flower; pods 2 to 3 seeded; seeds straw yellow with dark olive-brown hilum, about 3,246 to the pound; germ yellow; oil 19.6 per cent.

White Eyebrow.—Introduced under S. P. I. No. 30745 from Wulukai, Manchuria, in 1911. Plants stout, erect, bushy, maturing in about 110 days; pubescence both gray and tawny; flowers both purple and white, 35 to 40 days to flower; pods 2 to 3 seeded; seeds straw yellow with yellow hilum, about 3,000 to the pound; germ yellow; oil 19.8 per cent.

Wilson.—Introduced under S. P. I. No. 19183 from Newchwang, Manchuria, in 1906. Plants slender, erect, maturing in about 120 days; pubescence both gray and tawny; flowers both purple and white, 50 to 55 days to flower; pods

2 to 3 seeded; seeds black with black hilum, about 2,400 to the pound; germ yellow; oil 18.4 per cent.

Wilson-Five.—Selection from the Wilson variety at Arlington Experiment Farm, Va., in 1912. Plants slender, erect, with twining tips, maturing in about 120 days; pubescence gray; flowers purple, 50 to 55 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 5,025 to the pound; germ yellow; oil 15.2 per cent.

Wisconsin Black.—Received as Early Black by the Wisconsin Agricultural Experiment Station in 1898 and developed into a pedigreed strain. Plants stout, erect, bushy, maturing in about 100 days; pubescence tawny; flowers purple, 30 to 35 days to flower; pods 2 to 3 seeded; seeds black with black hilum, about 3,085 to the pound; germ yellow; oil 17.7 per cent.

Wisconsin Early Black.—The same as Wisconsin Black.

Wisconsin Pedigreed Black.—The same as Wisconsin Black.

Yoko.—The same as Yokoten.

Yokoten.—Introduced under S. P. I. No. 19981 from Japan in 1907. Plants stout, erect, bushy, maturing in about 120 days; pubescence gray; flowers both purple and white, 50 to 55 days to flower; pods 2 to 3 seeded; seeds straw yellow with brown hilum, about 2,175 to the pound; germ yellow; oil 19.9 per cent.

Yellow.—The same as Mammoth Yellow.

VARIETIES RECOMMENDED FOR DIFFERENT AREAS

The selection of a variety suited to local conditions and to the purpose for which the crop is grown is one of the best assurances against failure. The most suitable varieties for seed, pasture, hay, and silage are indicated in the following paragraphs which refer to numbered regions shown on the map (fig. 2). Outside of the regions numbered and described, except for limited areas in California, Arizona, and New Mexico, the soy bean can not be grown profitably or it is in the experimental stage. The following recommendations regarding varieties are based on extensive varietal experiments conducted in cooperation with State experiment stations and special cooperators:

Region 1.—Medium late, late, and very late varieties, maturing in 130 or more days, are grown for seed, hay, pasture, and silage. For seed: Biloxi, Chiquita, Dixie, Hollybrook, Mammoth Yellow, Southern Prolific, and Tokyo. For hay: Barchet, Chiquita, Goshen Prolific, Laredo, Old Dominion, Otootan, and Virginia. For pasture: Dixie, Easycook, Hahto, Hollybrook, Mammoth Brown, Mammoth Yellow, Southern Prolific, Tarheel Black, and Tokyo. For silage: Biloxi, Mammoth Brown, Mammoth Yellow, Tarheel Black, and Tokyo.

Region 2.—Late, medium late, and medium varieties, maturing in 120 to 140 days, for seed, hay, pasture, and silage, and very late varieties for hay, pasture, and silage. For seed: Chiquita, Dixie, Easycook, Haberlandt, Hahto, Herman, Hollybrook, Mammoth Yellow, Southern Prolific, Tokyo, and Yokoten. For hay: Barchet, Chiquita, Goshen Prolific, Herman, Laredo, Old Dominion, Otootan, Virginia, and Wilson-Five. For pasture: Dixie, Easycook, Haberlandt, Hahto, Hollybrook, Mammoth Brown, Mammoth Yellow, Southern Prolific, Tokyo, and Yokoten. For silage: Biloxi, Columbia, Mammoth Brown, Mammoth Yellow, Tarheel Black, Tokyo, and Virginia.

Region 3.—Medium and medium-late varieties, maturing in 110 to 130 days, for seed, hay, pasture, and silage, and medium-late and late varieties for hay, pasture, and silage. For seed: A. K., Austin, Dunfield, Easycook, Haberlandt, Hahto, Hongkong, Lexington, Manchu, Midwest, Mikado, Morse, Southern Prolific, and Yokoten. For hay: A. K., Arlington, Chiquita, Ebony, Herman, Ilsoy, Illini, Jet, Laredo, Merko, Peking, Sooty, Virginia, Wilson, and Wilson-Five. For pasture: Austin, Dixie, Haberlandt, Hamilton, Hongkong, Lexington, Manchu, Midwest, Mikado, Morse, Southern Prolific, and Yokoten. For silage: Austin, Columbia, Haberlandt, Hamilton, Hongkong, Ilsoy, Illini, Mammoth Brown, Morse, Peking, Tarheel Black, and Virginia.

Region 4.—Early and medium-early varieties, maturing in 100 to 120 days, for seed, hay, pasture, and silage and medium varieties for hay, pasture, and

silage. For seed: Aksarben, Black Eyebrow, Dunfield, Elton, Habaro, Ito San, Manchu, Minsoy, Pinpu, Soysota, Wea, and White Eyebrow. For hay: A. K., Black Eyebrow, Chernie, Chestnut, Ebony, Ilsoy, Illini, Ito San, Merko, Midwest, Peking, Wilson, Wilson-Five, and Virginia. For pasture: A. K., Aksarben, Black Eyebrow, Dunfield, Early Brown, Elton, Habaro, Hamilton, Hongkong, Hoosier, Manchu, Midwest, Soysota, and White Eyebrow. For silage: A. K., Black Eyebrow, Columbia, Dunfield, Hamilton, Manchu, Medium Green, Midwest, Peking, and Virginia.

Region 5.—Very early and early varieties, maturing in 90 to 110 days, for seed, hay, pasture, and silage. For seed: Aksarben, Black Eyebrow, Elton, Habaro, Ito San, Mandarin, Minsoy, Ogemaw, Soysota, and Wisconsin Black. For hay: Black Eyebrow, Chernie, Chestnut, Early Brown, Ito San, Merko, Minsoy, Soysota, and Wisconsin Black. For pasture: Aksarben, Black Eyebrow, Dunfield, Early Brown, Elton, Habaro, Hoosier, Ito San, Mandarin, Pinpu, Wea, and Wisconsin Black. For silage: Black Eyebrow, Elton, Habaro, Ito San, Manchu, Mandarin, Medium Green, and Wisconsin Black.

PREPARATION OF THE SEED BED

The best results with soy beans are obtained on a well-prepared seed bed. In general the land should be prepared as for corn. Soy beans, like corn, respond to any extra preparation of the soil. Fall or early spring plowing permits harrowing the soil before seeding and thus killing weeds just starting in the surface soil. On most soils disking alone is not sufficient, except after a crop of early potatoes or peas or after oat or wheat stubble where the land is moist and mellow. A firm seed bed with a light, loose covering of fine soil, well smoothed by the harrow, is conducive to uniform depth in seeding and to a good stand of plants. A soil free from clods insures the best results, especially in seeding broadcast, which may be desirable on the better types of soil and is coming to be practiced very generally in some of the Central and Western States.

Land which has been plowed early and prepared properly for soy beans and cultivated cleanly during the growing season furnishes without further preparation an excellent seed bed for wheat. In such a rotation it is essential to have a variety of soy beans that will mature for harvesting well ahead of the time for seeding wheat.

FERTILIZERS

When grown on land giving good yields of corn, or when grown following corn, as is frequently done, soy beans should produce a good crop without direct applications of fertilizers. The use of fertilizers, however, is to be recommended on sandy soils or soils of low fertility.

Extensive fertilizer experiments have been carried on by various agricultural experiment stations as to the fertilizer requirements of the soy bean. In general it has been found that the application of nitrogenous fertilizers is not necessary, as the soy bean, like other legumes, when inoculated assimilates the free nitrogen of the air. On soils of low fertility, however, an application of manure or nitrate of soda, cottonseed meal, or some other nitrogenous fertilizer added to the fertilizer mixture will be found advantageous in starting the crop.

Investigations show that where fertilizers are needed the best results are obtained with stable manure, or about 300 pounds of acid phosphate and 25 to 50 pounds of muriate of potash, or 250 pounds of

wood ashes if the potash is not available. When neither wood ashes nor potash are available, acid phosphate may be used alone to good advantage. In using commercial fertilizers it is advisable to work them well into the soil before seeding.

The soy bean is not so sensitive to lime as are red clover, alfalfa, and many other crops. The application of lime, however, has been found invariably to increase the yield of hay and seed and the nitrogen content of both vines and seed. Liming apparently stimulates the production of nodules, but the oil content of the seed has been found to decrease in direct proportion to the increased quantity of lime applied while the protein increases.

INOCULATION

Like other legumes, soy beans are able to utilize the nitrogen of the air through the action of bacteria which are on the roots of the plant. The presence of these organisms is indicated by the development of nodules or tubercles on the roots. (Fig. 3.) The bacteria of soy-bean nodules will not inoculate any other of the commonly cultivated legumes, nor will the bacteria found in the nodules of other legumes inoculate soy beans. Extensive bacteriological investigations during the last few years show that some varieties of soy beans are more difficult to inoculate than others. Different strains of soy-bean bacteria have been isolated which show differences in virility with different varieties of soy beans.

One of the most frequent causes of failure in growing soy beans the first time is the lack of proper inoculation. Where the crop is grown for the first time, soy beans make a rather indifferent growth unless inoculated. The lack of inoculation is nearly always indicated by a pale or yellowish green color of the plant. The soy bean, however, may give very good results on rich land, even though the bacteria are lacking; but in such cases the plant draws most of its nitrogen from the soil rather than from the air, as it does when inoculated.

Natural inoculation now occurs throughout much of the region where soy beans are extensively grown. To obtain the best results when the crop is planted on land on which it has not been previously grown it is advisable to inoculate. Inoculation is most easily accomplished when the soil is neutral or alkaline. Soy-bean bacteria, however, will thrive in a more acid soil than will those of most other legumes. When a soil once becomes thoroughly inoculated, no further attention to this feature is necessary, provided a crop of soy beans is grown occasionally on the land. The Wisconsin Agricultural Experiment Station [2] reports that in a fertile neutral loam soy-bean bacteria were known to have lived more than 18 years, but as a rule the number in a soil that has not grown the crop decreases rapidly after two or three years. The disappearance is more rapid in an acid than in a neutral or alkaline soil. At the Arlington Experiment Farm, Rosslyn, Va., fields were inoculated for soy beans about 20 years ago and no soy-bean bacteria have been applied since,

[2] FRED, E. B., and DAVENPORT, A. BACTERIA FOR LEGUMES. Wis. Univ. Col. Agr. Ext. Serv. Circ. 143, 23 pp., illus. 1922.

yet at the present time soy-bean plants on any portion of the farm bear an abundance of nodules.

Inoculation may be effected through the use of pure cultures of the bacteria or by the application of soil from a field where well-inoculated soy-bean plants were grown the preceding year. Cultures may be purchased from commercial seed firms, and many State

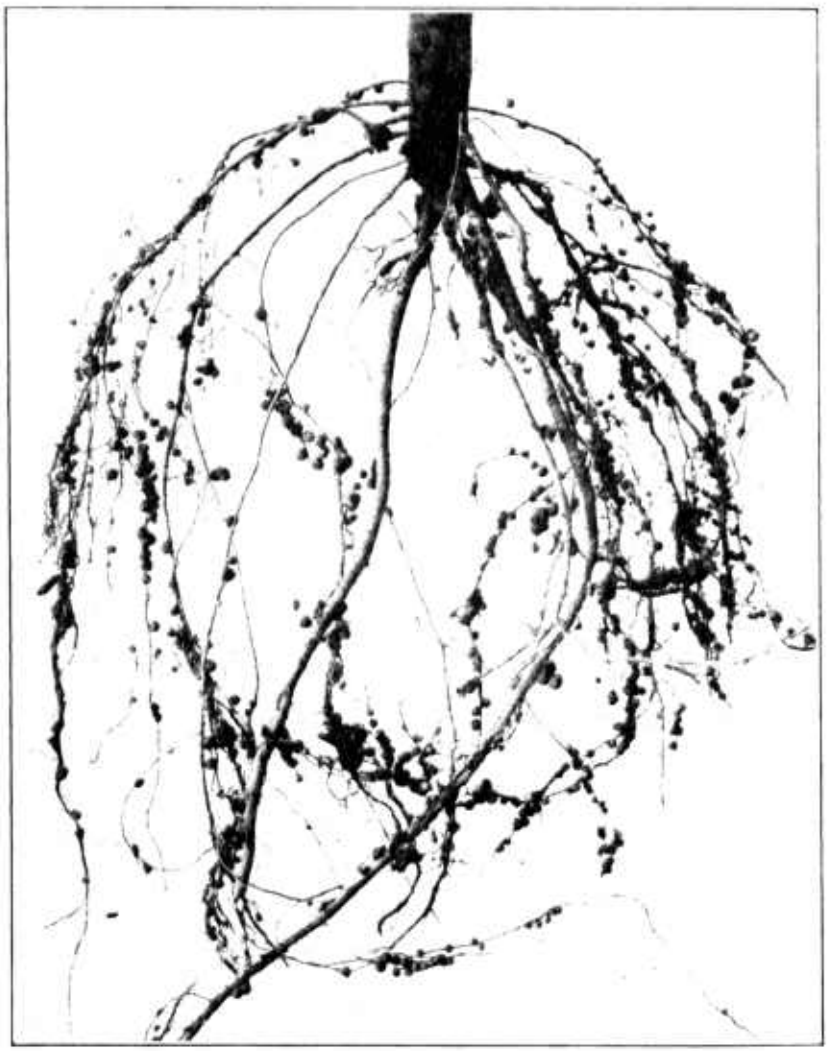

FIG. 3.—Roots of a soy-bean plant, showing abundant development of nodules

experiment stations furnish them at cost. These cultures are applied directly to the seed shortly before seeding.

The soil-transfer method is sometimes used, about 250 pounds of inoculated soil to the acre being broadcast and harrowed in. Although good results are obtained with this method, it requires considerable labor. The inoculated soil may also be sifted and

drilled through, using the fertilizing box at the time of seeding. Two quarts of finely sifted inoculated soil to a bushel of seed is sufficient if 3 ounces of glue or sugar is dissolved in 1 quart of water and the seed moistened with the solution before it is mixed with the soil. Another method is to make a thin mud of inoculated soil and water and apply it to the seed; or a bushel of seed may be thoroughly mixed with a gallon of finely sifted inoculated soil. After soy beans have been inoculated in one field on the farm, soil may be taken from this field to inoculate other fields.

Numerous investigations have been carried on with regard to the influence of inoculation on the growth and composition of the soy bean. The Michigan Agricultural Experiment Station[3] found that although the presence of the bacteria on the roots in a fairly fertile field did not notably increase the yield, the inoculated plants were richer in protein and therefore of greater value than the ones not inoculated. Similar results were obtained at the Wisconsin Agricultural Experiment Station,[4] indicating that inoculation is beneficial by increasing the nitrogen content of the plant, the percentage of fertilizing ingredients in the roots, and the protein content of the seed. It was also found that inoculation caused a decrease in the percentage of ash constituents in the plant and in the oil content of the beans. Analyses of seed of inoculated plants at the timothy-breeding station, North Ridgeville, Ohio, showed 42.47 per cent protein, and for seeds of plants not inoculated 35.26 per cent of protein.

TIME OF SEEDING

Soy beans may be sown during a period extending from early spring until midsummer, depending largely on the latitude and the use to be made of the crop.

For a grain or a main hay crop the best time for seeding is about corn-planting time, or when the ground has become thoroughly warm, as conditions then are favorable for the best germination and rapid growth of the crop. Soy beans germinate and grow very poorly in a cold, wet, or dry soil. Early seedings require longer than late seedings to mature, the difference in the same variety amounting to three weeks or more. Ordinarily there is no advantage in seeding earlier than corn-planting time, especially with the late varieties.

For pasturage, green manure, soiling, or even for hay the soy bean may be sown as late as August 1 in the South and July 1 in the North.

At the Tennessee Agricultural Experiment Station, the extreme dates of successful seeding were found to be April 3 and August 6, with June as the most favorable month for any variety. Tests made at the Iowa Agricultural Experiment Station over a period of six years, with seeding extending from April 18 to July 4, gave no differences in yield of either hay or seed for seedings made from the earliest date to June 7. Results of tests at the Missouri Agricultural Experiment Station show that the seeding period from June

[3] SMITH, C. D., and ROBISON, F. W. OBSERVATIONS ON THE INFLUENCE OF NODULES ON THE ROOTS UPON THE COMPOSITION OF SOY BEANS AND COWPEAS. Mich. Agr. Exp. Sta. Bul. 224: 127–132. 1905.

[4] WOLL, F. W., and OLSON, G. A. THE EFFECT OF SOIL INOCULATION ON THE DISTRIBUTION OF THE FERTILIZER INGREDIENTS IN SOY BEANS. Wis. Agr. Exp. Sta. Ann. Rpt. 24 (1906): 164–166. 1907.

1 to June 15 was more favorable than any other, both for the production of seed and of hay. The yields obtained from May seedings were fairly good, but those from April and July seedings were very poor. Similar results have been obtained at the Arlington Experiment Farm with a large number of varieties sown at two-week intervals beginning May 1 and extending to August 1, over a series of years.

METHODS OF SEEDING

Various successful methods of seeding soy beans are employed in different sections where large acreages are devoted to this crop. Soy beans are sown either in rows sufficiently wide to allow cultivation or in close drills. Broadcasting the seed and covering with a harrow is seldom practiced and is not advisable. When the crop is grown for the first time, it is generally best to seed in rows so that the weed growth can be kept under better control. The best method of seeding will be determined largely by convenience and economy of cultivation, rate of seeding, variety used, type of soil, climatic conditions, and the purpose for which the crop is grown.

For seed production the crop under nearly all conditions should be grown in rows and given sufficient cultivation to keep down the weeds. In some sections, especially in the Southeast, the row method is employed in the production of forage. In that section it is a common practice to grow the corn in rows from 6½ to 7 feet apart with rows of beans for seed production alternating between. The most desirable row space for soy beans varies under different conditions, and no general rule can be given for all types of soil. Usually, on fertile soils, rows from 24 to 36 inches apart give the best results, while on medium fertile and poor soils rows from 36 to 42 inches apart are most satisfactory. In some sections the highest yields of seed have been obtained from rows 21 to 30 inches apart. In the Southern States, where the larger and later varieties are used, soy beans are usually sown in rows 3 to 4 feet apart. In many sections of the Corn Belt experienced growers who use proper cultural methods are able to produce a crop of hay or seed more economically when closely drilled.

For hay, soiling, or green manure the soy bean is usually sown in close drills. If the land is free from weeds or is given a thorough cultivation with the harrow, weeder, or rotary hoe when the weeds are small, larger yields and a finer quality of forage will be obtained by drilling solidly. The main objections to this method are the larger quantities of seed required, the increased competition of weeds in cold, wet seasons, and the decreased yields of seed and forage under drought conditions.

When soy beans are to be seeded with corn for silage or pasture, various methods of growing are practiced. The beans may be sown in the same hill with the corn, in the same row with corn but in alternate hills, in alternate rows with corn (fig. 4), or with two rows of corn and two of soy beans alternating. The corn may be checked and the beans either checked with the corn or drilled, or both the corn and beans may be drilled. In the Southern States, especially North Carolina, soy beans are sown broadcast at the last working

of the corn for hog pasture. North of the Cotton Belt, soy beans sown at the last cultivation of corn seldom make a satisfactory growth.

The ordinary grain drill (fig. 5) furnishes, perhaps, the most satisfactory means for sowing either in rows or in close drills. The space between rows may be adjusted by covering the feed cups not wanted. To prevent splitting the seed, the oats feed should be used. Corn planters are also very generally used for sowing the beans either alone or with corn, as most of the modern planters have special plates for beans, or a special soy-bean attachment can be obtained for the planter. The practice of mixing the corn and soy beans and drilling from the same grain box does not give satisfactory stands of soy beans and corn. To some extent this may be overcome by using a small quantity of seed and stirring frequently, or by

FIG. 4.—Soy beans and corn planted in alternate rows

using a mixture of one-third soy beans and two-thirds corn and keeping the mixture uniform by occasional stirring. To insure even distribution for silage the practice of seeding the corn in checks and the soy beans with a hand planter one way between the corn hills gives excellent results. In some sections the corn is drilled in first, followed by drilling the soy beans. In the Southern States the cotton planter is extensively used. The sugar-beet drill may be also used for drilling soy beans in rows.

RATE OF SEEDING

The quantity of seed to be sown to the acre will necessarily vary somewhat, according to the variety, method of seeding, character of the soil, climatic conditions, and the purpose for which the crop is grown. Investigations indicate that the rate of seeding can vary

more or less without greatly affecting the yield of either forage or seed. As so many factors are involved, no standard rule can be given as to the exact quantity of seed to be used under general conditions.

Varieties of soy beans vary widely in size of seed (fig. 6), ranging from 1,250 to the pound for the Hahto to 9,950 to the pound for the Barchet. Furthermore, the size of the seed in the same variety will vary somewhat in different seasons and in different localities, depending largely upon soil and seasonal conditions.

Much heavier rates of seeding are practiced in those sections where the weeder, harrow, or rotary hoe are used for cultivation. At the Iowa Agricultural Experiment Station, extensive rate-of-seeding tests show that using double the ordinary quantity of seed recommended has given the most profitable yields of both forage and

FIG. 5.—The ordinary grain drill may be used for sowing either in rows or in close drills

seed. Heavier rates of seeding allow for a certain loss of plants which may result from thorough cultivation and also produce higher yields of finer forage. In moderately fertile to rich soils heavier seedings are generally practiced, but in the less fertile soils and under dry conditions lighter rates should prevail.

The quantities of seed required for cultivated rows vary from 10 to 75 pounds to the acre for the smallest to the largest seeded varieties, respectively. Investigations at the Arkansas Agricultural Experiment Station[5] indicate that the following formula may be used to calculate the exact quantity of seed to give any desired stand in row seedings when the number of seeds to the pound is known.

$$\text{Number of pounds to the acre} = \frac{43560 \times \text{number of seed per linear foot}}{(\text{Width of rows in feet}) \times (\text{number of seeds per pound})}.$$

[5] McCLELLAND, C. K. VARIETY AND ROTATION EXPERIMENTS WITH SOY BEANS. Ark. Agr. Exp. Sta. Bul. 199, 21 pp., illus. 1925.

For close drills or broadcast sowing, from two to two and one-half times the quantity of seed for rows is used.

The quantity of soy-bean seed sown in mixtures with other crops varies in different localities. When mixed with corn, the usual method in some sections is to mix the beans and corn in equal quantities and regulate the planter to drop seeds at about twice the ordinary

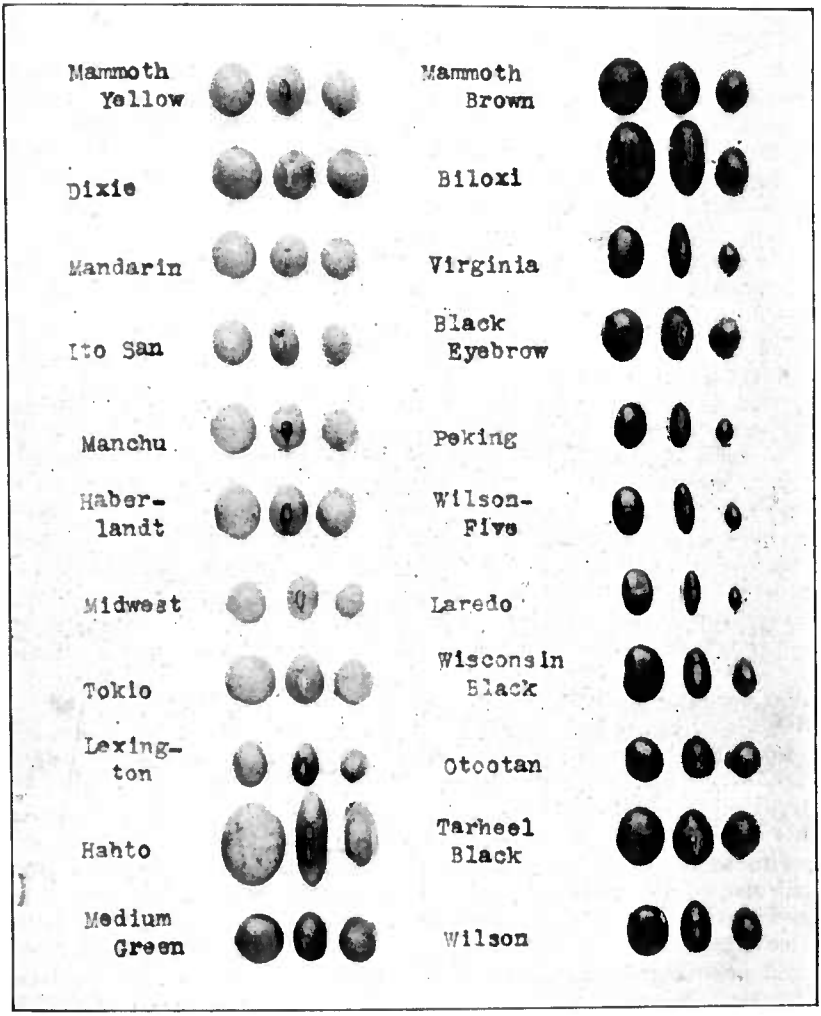

FIG. 6.—Seeds of the more important varieties of soy beans now grown in the United States, showing the wide range in the size of the seed

rate for sowing silage corn. Another method of mixing the seed is to add to the regular seeding of silage corn 6 to 8 pounds extra of soy-bean seed to the acre. Results from extensive investigations carried on by numerous experiment stations indicate that the most desirable rate is an average of two corn plants and from two to four soy beans per hill, or, if drilled, one corn plant every 12 to 16 inches and one soy-bean plant every 6 to 8 inches in the row.

DEPTH OF SEEDING

The depth of seeding is of much importance, as poor stands frequently result from covering too deeply, especially in the case of the large-seeded varieties. The most favorable depth is governed by the character of the soil, quantity of moisture present, and size of seed. In clay or heavier types of soil, shallow seedings, about 1 inch, tend to lessen the chance of failure due to the formation of a soil crust after heavy rains. In light loams or sandy soils the seeding may be deeper but should not exceed 3 inches. If the seeding is done during a dry period, 3 inches will not be too deep. General results show that small-seeded varieties like the Laredo, Barchet, and Otootan are able to come through deeper coverings of soil than large-seeded varieties like the Hahto, Biloxi, and Mammoth Yellow. However, even with the small-seeded varieties, covering too deeply should be avoided. In case of rain, a smoothing harrow, weeder, or rotary hoe may be employed to break any crust which may form on the surface. Under usual spring conditions comparatively shallow seedings will give the best results.

CULTIVATION

Under favorable conditions soy beans germinate in a few days and cultivation should begin as soon as the seedlings appear. When drilled or broadcast for hay or grain, or even when sown in rows if the weed seeds have germinated, a shallow cultivation with the weeder, harrow, or rotary hoe should be given before the seedlings break through the ground. Frequently a cultivation is necessary before the young plants appear, if the soil is of a heavy type and forms a heavy crust after a rain. As soon as possible after the crust forms, a light harrowing should be given to break the crust and allow the young plants to come up. The seedlings are very tender and easily broken off just as they are coming up, and cultivation should not be given unless the plants can not break through.

When soy beans are planted in close drills for hay or grain, the weeder, harrow, or rotary hoe may be used, if necessary, until the plants are 8 to 10 inches high. Experience has shown that the cultivation of drilled or broadcast seedings will give much larger yields of hay with a smaller percentage of weeds. Comparative experiments indicate that about the same results may be obtained in the use of the weeder, rotary hoe, and harrow. The rotary hoe (fig. 7) is a valuable implement to cultivate both closely drilled and row seedings. It is especially valuable for working soil that is packed and it gives excellent results when followed by a weeder or a harrow. In using the spike-tooth harrow, the teeth should be slanted backward slightly and the cultivations should be across the rows.

Usually soy beans in rows are cultivated with the ordinary corn cultivators. However, the harrow, weeder, or rotary hoe may be used as for close drills in the early stages of growth and reduce later work with the cultivator. The sugar-beet cultivator gives excellent results when the beans are grown in narrow rows.

Soy beans should be cultivated until about the blooming stage. At this period they should produce sufficient shade to control the growth

of weeds. Comparatively little injury results if they are cultivated during the heat of the day when the plants are tough. If continued after bloom, cultivation will cause injury to the blossoms and reduce the seed yield by breaking the branches. It is not advisable to cultivate soy beans when they are tender from rain or dew, as the plants are then easily bruised and broken. Level cultivation is preferable, as it makes harvesting easier.

SOY BEANS IN ROTATIONS

The soy bean may be used advantageously as either a grain crop or a hay crop in many systems of crop rotations, but no standard rotation can be given that will apply to every farm. The place of the soy bean in any rotation system will depend on the soil, the purpose for which the crop is grown, and the other crops used

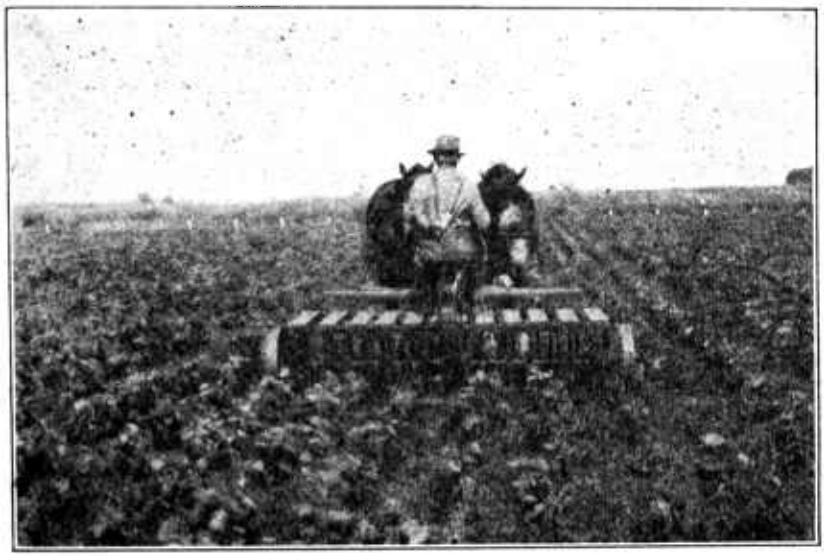

FIG. 7.—The rotary hoe is an excellent implement for either solid or row plantings

in the rotation. The soy bean is especially valuable in short rotation with corn, cotton, and small grains, as an entire-season or a part-season crop. When the whole season is devoted to soy beans, they may occupy any place in a rotation system where corn can be used. In regions where cowpeas are grown, soy beans are adapted to practically the same place in rotations as cowpeas.

When small grains follow soy beans, little preparation of the land is necessary for seeding the grain. In some sections a soy-bean crop is often grown between two wheat crops or two oat crops. A rotation of corn, soy beans, wheat, and clover is very common in many sections north of the Ohio River. Soy beans may be profitably substituted for oats in such four-year rotations as corn, oats, wheat, and clover or potatoes, oats, wheat, and clover.

Results obtained over a period of 15 years in the rice-growing district of Louisiana show that where the soy bean has been grown

in rotation with rice, weeds, especially red rice, have been eradicated, a better quality of seed has been produced, and the yields of rice have been greater than where commercial fertilizers were used.

The soy bean can also be used as a catch crop where new seedings of grass and clover have failed and on wheat or oat stubble fields where clover or grass has not been sown or has not succeeded. As a crop after early potatoes or canning peas and as an orchard cover crop the soy bean is highly recommended, as it will produce a large quantity of fall pasturage or material for plowing under on soils in need of organic matter.

FIG. 8.—Soy beans seeded in the same row with corn. They are more generally grown with corn than with any other crop

SOY BEANS IN MIXTURES

Soy beans may be satisfactorily grown in combination with other crops, such as corn, cowpeas, Sudan grass, Johnson grass, and sorghums. The chief advantage of the mixture is the production of better balanced feed, and the yields are often somewhat better than when the crops are grown separately. The practice of combining soy beans with other crops, especially corn, has increased very rapidly during the last few years, indicating that the results are highly satisfactory.

SOY BEANS AND CORN

Soy beans are more generally grown with corn than with any other crop. (Fig. 8.) When soy beans are grown with corn the mixture is commonly used for pasturage or silage. In some of the Southern States corn and soy beans are grown in alternate rows for seed production.

Extensive investigations have been carried on in various sections of the country to determine the results that may be expected from a mixed planting of soy beans and corn. Experimental evidence and general observations indicate that such a mixture results in a reduction in the yield of corn, especially of the grain, the decrease depending largely upon the thickness of the stand of both soy beans and corn. The smaller yield of corn may be partly compensated for by the yield of soy beans.

At the Iowa Agricultural Experiment Station[6] soy beans in corn decreased the yield of corn 6.76 to 25.15 per cent, depending upon the rate of seeding. The yield of soy-bean seed did not equal the loss in yield of corn in a single case, but the mixed planting in the grain series produced on the average 28.25 per cent more protein than corn alone. Experiments over a period of six years at the Missouri Agricultural Experimental Station[7] show that soy beans drilled with corn invariably reduced the yield of corn, but that in the better ratios the combined yields were as large as or slightly larger than those of corn alone. At the Kentucky Agricultural Experiment Station[8] results for six years showed an average loss of 5.7 bushels of corn and a yield of 3.5 bushels of soy beans per acre. The Tennessee Agricultural Experiment Station[8] in a 4-year test found that a loss of 618.2 pounds of shelled corn was more than balanced by 724.5 pounds of soy beans. At the Illinois Agricultural Experiment Station[8] over a period of four years there was an average loss of from 10.1 to 12.5 per cent of shelled corn when soy beans and corn were grown together. The yield of soy beans did not equal this loss except in one instance.

Although the seeding of soy beans and corn for silage is very generally practiced, extensive investigations have given widely varying results not only from the standpoint of yields but also from that of the feeding value of the mixture. At the Iowa Agricultural Experiment Station[8] larger yields of silage were obtained when soy beans were seeded in corn than when corn was grown alone. Soy beans produced an average increase of approximately 1 ton of green forage or 500 pounds of dry matter per acre over corn alone at the Connecticut (Storrs) Agricultural Experiment Station.[9] Results obtained by the Pennsylvania Agricultural Experiment Station[10] show that soy beans grown with corn for silage did not give increases in yield of total material over corn alone, but it was found that the presence of 10 per cent or more of soy beans with the corn appreciably increased the percentage of protein in the silage. Experiments conducted with corn and soy beans by the Virginia Agricultural Experiment Station[11] show that in favorable seasons the yield of corn was not reduced by the beans, but in dry years it was. In no year, however, was the yield of the mixture less than that of corn alone.

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[6] THATCHER, L. E., and OHIO AGR. EXP. STA. Mimeographed report of some unpublished data from several State experiment stations in growing corn and soy beans together for grain and silage.

[7] ETHERIDGE, W. C., and HELM, C. A. CORN AND SOY BEANS. Mo. Agr. Exp. Sta. Bul. 220, 23 pp., illus. 1924.

[8] HUGHES, H. D., and WILKINS, F. S. SOY BEANS FOR IOWA. Iowa Agr. Exp. Sta. Bul. 228, 16 pp., illus. 1925.

[9] SLATE, W. L., and BROWN, B. A. CORN AND SOY BEANS AS A COMBINATION CROP FOR SILAGE. Conn. (Storrs) Agr. Exp. Sta. Bul. 133; 351–376, illus. 1925.

[10] NOLL, C. F., and LEWIS, R. D. SOY BEANS. Pa. Agr. Exp. Sta. Bul. 167, 20 pp., illus. 1921.

[11] WOLFE, T. K. SOY-BEAN CULTURE. Va. Agr. Exp. Sta. Bul. 235, 32 pp., illus. 1924.

SOY BEANS AND COWPEAS

Soy beans and cowpeas when sown together make a very satisfactory mixture for hay or pasture. With this mixture the yield is nearly always greater than that of either crop alone, and the curing of the cowpeas is easier because of the soy-bean plants. Varieties of these crops that mature at about the same time should be used. The Whippoorwill, New Era, and Groit cowpeas can be grown to good advantage with Wilson, Wilson-Five, and Virginia soy beans for forage purposes. The later varieties of cowpeas, as Unknown (Wonderful), Brabham, Iron, and Red Ripper, should be grown with varieties of soy beans maturing at the same time as the Mammoth Yellow.

In sowing a mixture of soy beans and cowpeas it is best to have more soy-bean plants than cowpeas so that the vining cowpeas may have support. From 1 to 1½ bushels of soy beans and one-half to 1 bushel of cowpeas are required per acre in close drills, while in 3-foot rows one-half of these quantities is sufficient. The seed can be sown best with an ordinary grain drill.

The time of cutting for hay will depend on the relative growth of the two crops. Both plants should be cut at that stage of growth giving the best quality of hay, which is when the soy-bean seed is one-half to full grown and the first pods of the cowpeas are mature. The harvesting and curing of a cowpea and soy-bean mixture for hay are more easily accomplished than in the case of cowpeas alone, but are slightly more difficult than with soy beans alone. As with other legumes, care should be taken in handling the hay to prevent the loss of leaves.

SOY BEANS AND SUDAN GRASS

Sudan grass is an excellent crop for growing in combination with soy beans (fig. 9). The best results with this mixture are obtained in the regions most suitable for soy beans or where irrigation is possible. Under such conditions not only a better yield but a better balanced forage is obtained, as the Sudan grass is low and the soy bean high in protein. Under semiarid conditions Sudan grass invariably crowds out the soy bean. The harvesting of the mixture is easy, as the erect, stiff stems of the Sudan grass support the soy-bean plants, which tend to vine more or less when grown in combination with other crops. This mixture is cut for hay about the time the soy-bean seed is half grown.

The planting of Sudan grass and soy beans as a main hay crop has increased rapidly during the last few years. Extensive tests carried on in several States show the yields to range from 2 to 4 tons to the acre. The best results are obtained by seeding with a grain drill about 60 pounds of soy beans and 10 pounds of Sudan grass to the acre.

SOY BEANS AND MILLET

Soy beans and millet are not especially recommended as a mixture. The millet matures earlier than any of the better varieties of soy beans. The best results have been obtained by sowing 1 bushel of the Wilson or Virginia varieties of soy beans and 20 pounds of millet to the acre.

INSECT ENEMIES OF SOY BEANS[12]

Soy beans usually are comparatively free from serious insect pests. It is probable that when this crop is more extensively grown insect enemies will multiply and new foes of the plant will develop. At present, however, the seriously injurious kinds may almost be counted on the fingers of one hand. They are grasshoppers, blister beetles, leaf hoppers, the Mexican bean beetle, and the green clover worm. Most of the caterpillars that feed habitually on legumes, such as clover, alfalfa, and cowpeas, will feed occasionally upon soy beans. Among these are the army worms, the garden webworm, the rose leaf tier, and others. Aphids occasionally are troublesome, but their attacks usually are sporadic and seldom can be met successfully.

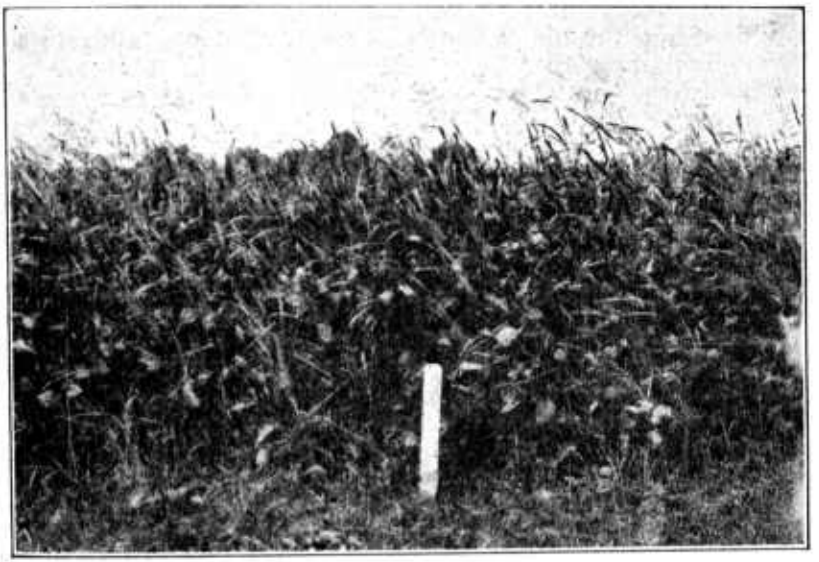

FIG. 9.—A field of soy beans and Sudan grass grown in mixture for hay

Most of the beetle enemies of alfalfa and clover may be expected to feed upon soy beans to some extent when their welfare or survival requires it.

GRASSHOPPERS

The grasshoppers attacking soy beans belong to the species commonly injurious to alfalfa throughout the country, such as the red-legged,[13] lesser migratory,[14] and differential[15] grasshoppers. They are more likely to become injuriously numerous in semiarid climates, but during dry summers they may multiply sufficiently to cause serious injury wherever soy beans are grown. Fortunately, grasshoppers attacking soy beans may be destroyed by means of the usual

[12] Prepared by W. R. Walton, entomologist, Cereal and Forage Insect Investigations, Bureau of Entomology.
[13] *Melanoplus femur-rubrum* DeG.
[14] *Melanoplus atlanis* Riley.
[15] *Melanoplus differentialis* Thom.

remedy, which consists in the application of poison-bran bait prepared as follows:

Wheat bran	50 pounds.
Paris green or crude arsenic	2 pounds.
Molasses	1 gallon.
Water	6 gallons.
Amyl acetate	1½ ounces.

The poison and the bran should be very thoroughly mixed while dry. The molasses and the water are stirred together and the amyl acetate is added to this liquid. It is not necessary to use the chemically pure preparation of amyl acetate, as a technical grade is perfectly satisfactory. The bran should be thoroughly wet with the liquid, but should not be wet enough to interfere with ease in distribution. This bait should be scattered broadcast thinly and uniformly at the rate of about 8 to 10 pounds (wet weight) to the acre. If the bait be distributed in lumps there may be danger of poisoning fowls or farm animals, but there is no danger whatever of this when it is properly distributed. The best time for scattering the bait is in the early morning.

BLISTER BEETLES

In recent years blister beetles of several species,[16] commonly known as Spanish flies, have become so injurious to soy beans in some of the Southern and Western States as to occasion considerable alarm. The beetles usually appear very suddenly and feed so rapidly as to strip the plants completely in a short time. The young or larvæ of these beetles devour the eggs of grasshoppers, and in this respect the insects are of considerable benefit. When the adult beetles attack crops, they may be destroyed effectively by dusting the infested plants with a mixture of equal parts of powdered sodium fluosilicate and hydrated lime at the rate of about 15 pounds to the acre. Sodium fluosilicate is a comparatively new insecticide which is a by-product of the manufacture of acid phosphate and is poisonous to man in about the same degree as is arsenic. When applied as recommended this insecticide kills the beetles within 24 hours and the plants suffer no appreciable injury. Arsenic in any form is not very effective for these insects.

MEXICAN BEAN BEETLE

Soy beans sometimes are attacked by the Mexican bean beetle,[17] although it evidently prefers other legumes as food. It is very possible that in time this insect may become adapted to soy beans and become a serious pest. When it becomes necessary to protect this crop against attacks of this insect and the plant is not being grown for hay, it may be sprayed with a mixture of calcium arsenate 2 pounds, hydrated lime 3 pounds, and water 100 gallons. Since the Mexican bean beetle feeds on the under surfaces of the leaves, it is necessary to adjust the spray nozzles so as to apply the spray to these parts of the plants. The spray should be applied at the rate of 90 to 100 gallons to an acre. When the crop is to be used for hay and becomes infested, immediate cutting is recommended.

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[16] *Epicauta vittata* Fab., *E. pennsylvanica* DeG., *E. lemniscata* Fab.
[17] *Epilachna corrupta* Muls.

OTHER BEETLE ENEMIES

Among the other beetles that occasionally attack soy beans is the clover root curculio.[18] It is a small beetle with a grayish snout which lives normally on clover and alfalfa. It gnaws the buds and foliage of soy beans and other legumes and may injure the crowns and roots of the plants. Where this insect is numerous it is advisable to plant soy beans in rotation with clover.

The bean leaf beetle[19] occasionally feeds upon soy beans as well as cowpeas and garden beans. It resembles in a general way the spotted cucumber beetle. The larvæ of this insect may also feed upon the nitrogenous nodules on the roots of the plants. The adults gnaw holes in the leaves and may be poisoned with arsenate of lead, as recommended for caterpillars, or with the calcium-arsenate-lime mixture, as recommended for the Mexican bean beetle. These poisons should be applied as soon as the beetles appear.

Flea beetles[20] of several species are especially numerous in the Gulf States, and frequently attack soy beans. They may be repelled or poisoned, where necessary, by the foregoing methods.

LEAF HOPPERS

Among the more common leaf hoppers attacking soy beans are the potato leaf hopper[21] and a species known as *Agallia sanguinolenta* Prov., which has no common name. These insects puncture the leaves with their beaks and feed upon the sap of the plants. They can not be combated successfully by the application of arsenical insecticides, but require the use of contact poisons, most of which are more or less expensive to use. A mixture of one-half pint of 40 per cent nicotine in 50 gallons of soapy water applied as a spray should be effective when used against these insects on soy beans, although very little experimental work has been done with leaf hoppers on this crop. The young or wingless forms are killed readily by this mixture, but the adult insects do not succumb so easily. Bordeaux mixture has been found to give protection when used as a spray against leaf hoppers on field and garden beans, but little is known regarding its effects when applied to soy beans.

ARMY WORMS AND OTHER CATERPILLARS

Nearly all caterpillars that feed upon soy beans may be destroyed by similar methods. As they swallow large quantities of the leaves, it is possible to poison them quickly by applying to the plants any safe arsenical poison that may be available. Of such poisons, arsenate of lead is perhaps the least likely to burn the plants. When used as a spray, 1 pound of powdered arsenate of lead to 50 gallons of water is effective for caterpillars such as the army worm,[22] the fall army worm,[23] climbing cutworms, the corn ear worm,[24] or their relatives, when feeding on forage crops.

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[18] *Sitona hispidulus* Fab.
[19] *Cerotoma trifurcata* Forst.
[20] *Systena blanda* Melsh. and others.
[21] *Empoasca mali* LeB.
[22] *Cirphis unipuncta* Haw.
[23] *Laphygma frugiperda* S. and A.
[24] *Heliothis obsoleta* Fab.

Where it is desired to destroy army worms of either kind without applying the poison directly to the soy beans, this may be accomplished by distributing the poisoned bait as recommended for the destruction of grasshoppers. This bait is a standard insecticide for such caterpillars and usually is very effective. It is of course necessary in all cases to apply such remedies before the plants have been defoliated.

Caterpillars that feed within webs, such as the garden webworm, are difficult to control with poison. Where the crop is being raised for hay and becomes infested with such caterpillars immediate cutting is recommended.

THE GREEN CLOVER WORM

The green clover worm,[25] which is the caterpillar of an inconspicuous, soot-colored moth, feeds upon a variety of plants of the bean family and ordinarily escapes the notice of growers. In 1919, however, it caused widespread injury to soy beans in the South Atlantic Coastal Plain region. Many fields were so defoliated that they did not produce a crop. The following year the insects were present in smaller numbers, and no recurrence since has been recorded. The green clover worm is always present in the region mentioned, however, and may at any time become numerous enough to repeat the severe injury of 1919. In case this worm becomes abundant again its control may be accomplished by dusting with the following mixture:

Lead arsenate (powdered)	1 pound
Hydrated lime	8 pounds

This dust should be applied evenly but thinly at the rate of about 18 pounds to 1 acre of soy beans. Any efficient form of hand or power duster may be used. It is possible to apply such a dust by hand, but this is a tedious process and requires considerably more of the dust than where a machine is used.

The poison should be applied as promptly as possible after the infestation is noticed. Unless the beans are cut for forage very soon after applying the poison there is no danger of poisoning stock in feeding.

CHINCH BUGS

There is good evidence to show that injury to corn by the chinch bug[26] is considerably lessened by the practice of growing soy beans with the corn. This insect thrives best in locations that are dry and warm. There is a fatal fungous disease that attacks it under humid conditions. Where soy beans are grown with the corn they produce a dense shade about the lower parts of the plant that is unfavorable for the bugs. Extensive experiments conducted by the Illinois Agricultural Experiment Station demonstrated that the bugs were much less numerous on corn grown with soy beans than on corn grown alone. Fields planted to soy beans and corn produced good crops, while in adjoining fields of corn alone the crop was destroyed or very severely injured.

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[25] *Plathypena scabra* Fab. [26] *Blissus leucopterus* Say.

DISEASES OF THE SOY BEAN [27]

Although the soy bean is affected by several destructive diseases in Asiatic countries, as yet no disease of this plant has assumed any great economic importance in America. It is attacked, however, by several fungous and bacterial diseases in the United States; nevertheless, the crop is less affected by serious diseases than are many forage and food plants. More or less detailed studies have been made of those diseases reported in sections where soy beans are extensively grown.

BACTERIAL BLIGHT

Bacterial blight caused by *Bacterium glycineum* [28] has been reported from various parts of the United States. This disease occurs very commonly, especially on the leaves, where it produces small, angular spots which are at first yellow or light brown in color but later become dark brown to nearly black. The diseased tissues may eventually become dry and drop out, giving the leaves a ragged appearance. Investigations show that it is a seed-borne disease. Under favorable conditions, it spreads rapidly from the point of original infection to adjacent plants. Studies show that soy-bean varieties vary greatly in their relative susceptibility to bacterial blight, the Midwest variety being especially susceptible.

Another bacterial blight caused by *Bacterium sojae* [29] has been found in North Carolina. This disease resembles that caused by *Bacterium glycineum* so closely that it is doubtful if they could be differentiated with certainty in the field.

BACTERIAL PUSTULE

Bacterial pustule is a disease that is confined apparently to the foliage and is quite distinct from bacterial blight and other bacterial diseases of the soy bean. It is caused by the organism *Bacterium phaseoli sojense.* [30] Bacterial pustule is prevalent in North Carolina and is known to occur also in Texas, Louisiana, South Carolina, Virginia, Arkansas, Delaware, and Kansas. In the later stages this disease is characterized by angular, reddish brown spots on the leaves, varying in size from small specks to large, irregular, brown areas. Frequently the leaves have a ragged appearance due to the dropping out of portions of the larger spots.

MOSAIC

Soy-bean mosaic [31] has been reported from several States, but the disease does not appear to have become very prevalent as yet. The symptoms resemble those characterizing mosaic diseases in general. Plants affected with mosaic become stunted, petioles and

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[27] Prepared with the advice and cooperation of J. L. Weimer, associate pathologist, Office of Vegetable and Forage Diseases, Bureau of Plant Industry.

[28] COERPER, F. M. BACTERIAL BLIGHT OF SOY BEAN. Jour. Agr. Research 18: 179–194, illus. 1919.

[29] SHUNK, I. V., and WOLF, F. A. FURTHER STUDIES ON BACTERIAL BLIGHT OF SOY BEAN. Phytopathology 11: 18–24, illus. 1921.

[30] HEDGES, F. A STUDY OF BACTERIAL PUSTULE OF SOY BEAN AND A COMPARISON OF BACT. PHASEOLI SOJENSE HEDGES WITH BACT. PHASEOLI EFS. Jour. Agr. Research 29: 229–251, illus. 1925.

[31] KENDRICK, J. B., and GARDNER, M. W. SOY-BEAN MOSAIC: SEED TRANSMISSION AND EFFECT ON YIELD. Jour. Agr. Research 27: 91–98. 1924.

internodes are shortened, and leaflets are misshapen and puckered with dark-green puffy areas along the veins. The pods are stunted and flattened and the yield of seed is materially reduced. Varietal differences in regard to susceptibility have been found. Mosaic has appeared most prevalent in the Midwest, Haberlandt, and Black Eyebrow varieties, the Midwest proving very susceptible. The Soysota and Virginia varieties have escaped infection. It has also been found that varieties seem to differ in their ability to transmit mosaic through the seed. The Midwest, Haberlandt, Black Eyebrow, A. K., and Arlington varieties readily transmit mosaic, while seed selected from healthy plants produce mosaic-free seedlings. The yield of seed is reduced 30 to 75 per cent by mosaic.

FUSARIUM BLIGHT OR WILT DISEASE

Investigations show that the fusarium on soy beans is identical with the organism (*Fusarium tracheiphilum*[32]) producing the wilt of cowpeas. The disease is characterized by a chlorosis and shedding of the leaves or leaflets, followed by the death of the plants. It has been observed in several localities in North Carolina on soils infected with cowpea wilt and reported also in Louisiana and Alabama. Infection is thought to occur through the roots. The character of the soil appears to influence the amount of infection, the largest proportion of diseased plants occurring in coarse, sandy soils. Root rots caused by *Rhizoctonia* and *Sclerotium rolfsii* and other root injuries are believed to increase materially the percentage of diseased plants in the field. In investigations on the susceptibility of different varieties of soy beans, made at the North Carolina Agricultural Experiment Station, the Black Eyebrow variety was found to show resistance. The Mammoth Brown and Haberlandt varieties, while not free from the disease, developed well in spite of rather severe fusarium and nematode infection. At Monetta, S. C., the Laredo and two unnamed varieties appeared highly resistant to wilt.

STEM ROT

Stem rot is a disease caused by a fungus, *Sclerotium rolfsii*, that forms round, brownish bodies about as large as mustard seed on the roots of the soy-bean plant. The root dies and the whole plant gradually succumbs. It has been noted in Mississippi and several other Southern States, but thus far has not been very serious. In some small areas in the delta section of Mississippi 25 to 30 per cent loss has been reported, whereas in other cases about 5 per cent of the plants have been killed.

POD AND STEM BLIGHT

Pod and stem blight is a disease which is caused by the fungus *Diaporthe sojae*[33] and has been reported as occurring in North Carolina, Indiana, and Delaware. It attacks pods, stems, and less often the foliage, causing a premature death of the plants, failure of the

[32] CROMWELL, R. O. FUSARIUM BLIGHT OF THE SOY BEAN AND THE RELATION OF VARIOUS FACTORS TO INFECTION. Nebr. Agr. Exp. Sta. Research Bul. 14, 43 pp., illus. 1919.

[33] LEHMAN, S. G. POD AND STEM BLIGHT OF SOY BEAN. Ann. Missouri Bot. Gard. 10: 111–178, illus. 1923.

young seed to develop, and a molding and decay of the seed in the later stages of development. The organism winters over on stems and seed. Humidity is conducive to infection and dissemination of the disease. The use of disease-free seed and crop rotation are recommended as control measures.

SUNBURN

Investigations of a diseased condition of soy beans at the Arizona Agricultural Experiment Station [34] indicated that the primary cause was sunburning of the leaves or aphid injury, fungus infection being secondary. The fungus was isolated and is described as *Alternaria atrans*. The first indication of the disease is said to be the appearance of small, brick-red spots on the upper surface of the leaves, usually between the veins. Field and laboratory tests with the Ototan, Biloxi, Virginia, Mandarin, Barchet, Tarheel Black (Shanghai), Tokyo, and Peking varieties of soy beans showed sunburn and injury by the fungus on all varieties except the Biloxi. The Virginia variety was especially susceptible.

DOWNY MILDEW

Downy mildew is a leaf-spot disease caused by the organism *Peronospora sojae*. It is reported by the North Carolina Agricultural Experiment Station [35] as occurring in several places in North Carolina and is also reported in Delaware, Mississippi, Louisiana, Alabama and Kentucky. The disease is characterized by indefinite chlorotic areas, which change to grayish brown lesions with well-defined, dark-brown borders. Grayish colored masses of conidiophores are usually present on the under surfaces of the lesions.

ANTHRACNOSE

In North Carolina [36] soy-bean plants were found whose pods bore lesions which were incrusted with conidia of a fungus belonging to the genus Colletotrichum. The organism was identified as that causing anthracnose, *Glomerella cingulata*.

ROOT KNOT

Root knot is caused by a tiny eelworm or nematode (*Heterodera radicicola*) which lives for the most part in the roots of cultivated plants. It bores its way into the young roots, procures its food from them, and so irritates the tissues that galls are produced. The food supply is used up or its passage upward is prevented by galls, which results in the stunting or death of the plant. Instead of normal roots as found in healthy plants, those attacked by root knot have numerous irregular swellings or galls over the entire root system (fig. 10). The root-knot galls are quite different from the nodules of the beneficial nitrogen-gathering organism. Nodules are attached loosely

[34] GIBSON, F. SUNBURN AND APHID INJURY OF SOY BEANS AND COWPEAS. Ariz. Agr. Exp. Sta. Tech. Bul. 2: 41–46, illus. 1922.
[35] LEHMAN, S. C. A NEW DOWNY MILDEW ON SOY BEANS. Jour. Elisha Mitchell Sci. Soc. 39: 164–169, illus. 1924. Abstract in Phytopathology 14: 28. 1924.
[36] WOLF, F. A., and LEHMAN, S. G. BACTERIAL BLIGHT. N. C. Agr. Exp. Sta. Ann. Rpt. 43: 57. 1920.

to the roots, whereas root-knot galls are enlargements of the roots themselves. Root knot often causes considerable injury to soy beans in many parts of the Southern States where this pest is prevalent.

The most effective and practical method of controlling root knot combines the use of resistant varieties of soy beans with other

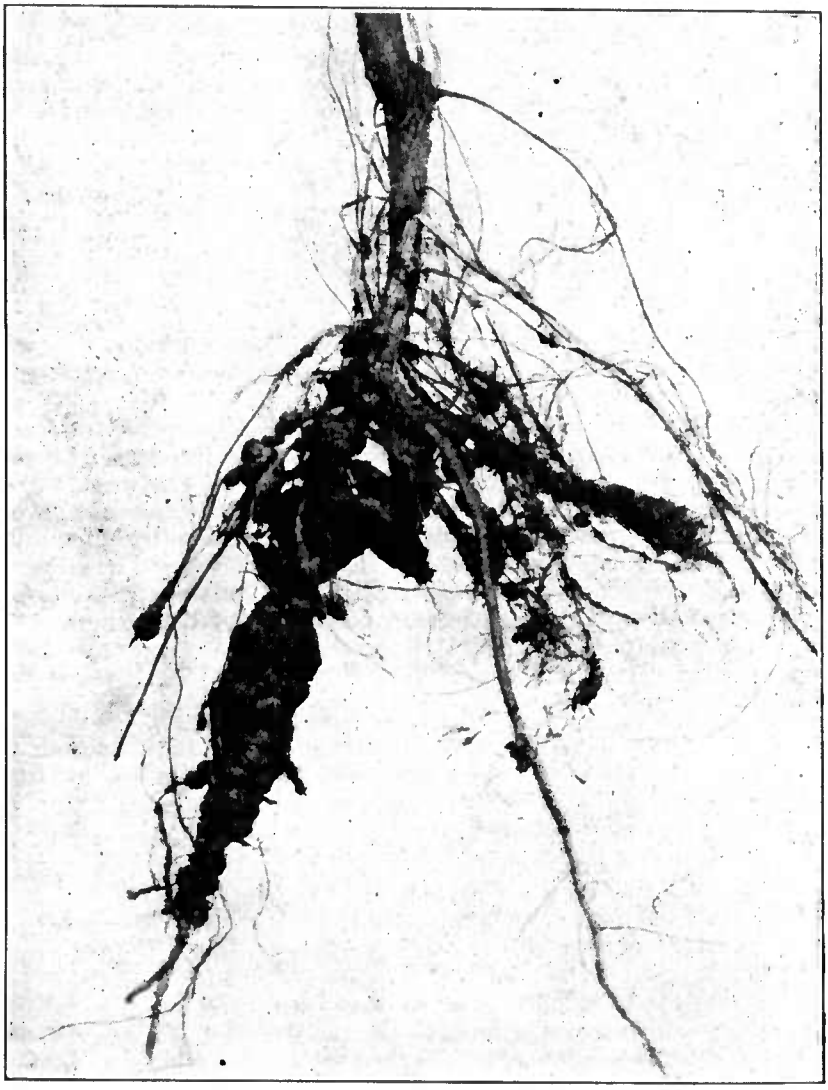

FIG. 10.—Roots of a soy-bean plant, showing galls caused by the nematode *Heterodera radicicola*

known immune crops in the rotation. Susceptible varieties of soy beans or other crops should not be planted on infested land until it has been rotated for one to three years with immune crops to starve out the nematodes.

Soy-bean varieties vary markedly in resistance to root knot, the Laredo variety thus far showing the greatest resistance.

OTHER ENEMIES OF SOY BEANS

Rabbits are exceedingly fond of the soy bean and when numerous cause considerable damage. In parts of the Great Plains area where moisture conditions are favorable and in the Gulf Coast region failures with the soy bean have been due chiefly to rabbits. The greatest damage is done while the plants are young and tender. Numerous observations have been reported where rabbits showed particular preference for certain varieties of soy beans. In a variety test in South Carolina the Barchet, Riceland, Tokyo and Chiquita varieties were kept eaten down the entire season, while other varieties were but slightly damaged and a few varieties remained untouched. In Oregon the Black Eyebrow, Ito San, and Guelph varieties were more or less damaged by rabbits, while the Manchu was not injured. Where rabbits are abundant soy-bean culture is practically impossible unless the field can be inclosed with rabbit-proof fencing or very large areas of the crop grown. The dusting of the plants on the outer rows with lime and either dusting or spraying with some arsenical poison have prevented serious damage from rabbits.

In the Northern States reports have been made of damage to small areas of soy beans by woodchucks.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

August 23, 1928

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